Photogrammetry: DTM Extraction & Editing

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How can one determine the x, y, and z of a location?

Approaches to DTM Extraction

- Ground surveying
- Digitized topographic maps
- Traditional photogrammetry
  - Hardcopy vs. softcopy approach
- Radar
- LIDAR

Photogrammetry

- The science of making reliable measurements by the use of photographs and especially aerial photographs.

- Challenges:
  - Geometric distortions (transformation)
  - Relief displacement (ortho-rectification)
  - Obscured targets (true-orthorectification)

Distortion

- Distortion: shift in the position of an image on a photograph that alters the perspective characteristics of the image.

- Displacement: shift in the position of an image on a photograph that does not alter the perspective characteristics of the photo

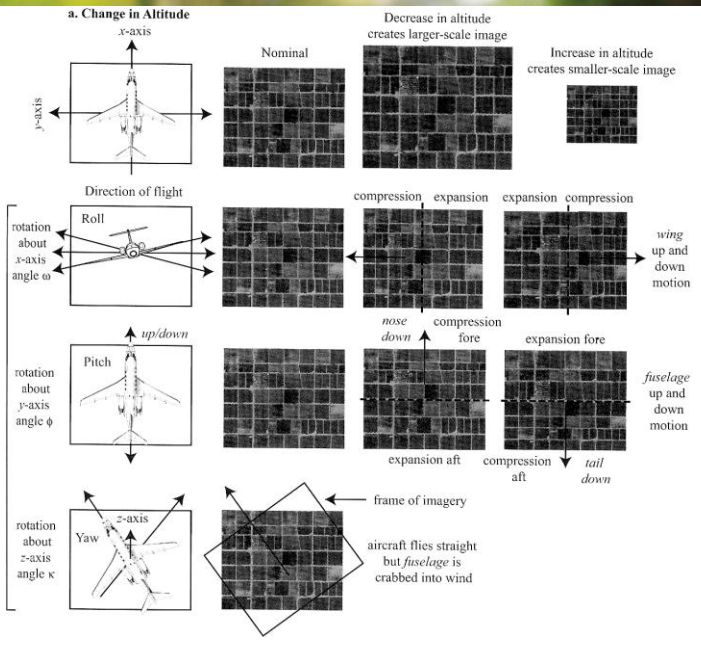
Types of Distortion

- Film and print Shrinkage
- Atmospheric Reaction of light rays (refraction)
- Image motion
- Lens Distortion

The effects of film shrinkage, atmospheric refraction are usually negligible in most cases.

Geometric Distortions

- External errors
  - Altitude changes
  - Attitude changes (roll, pitch, and yaw)
- Internal errors
  - e.g., lens distortion, earth rotation



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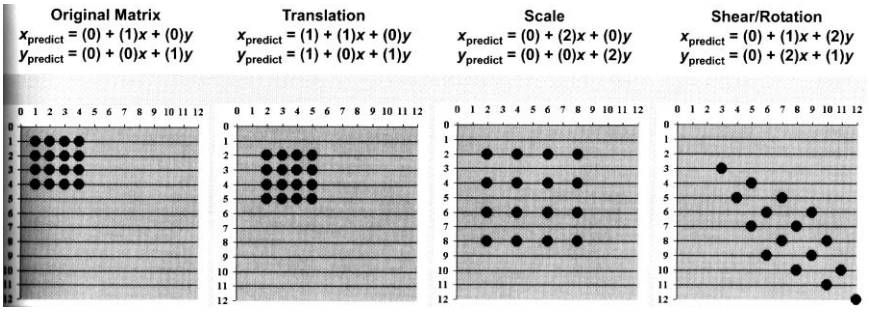
Methods of Correcting Geometric Distortion

- Affine Transformation (aka linear or first-order transformation)
- Higher order polynomial transformation



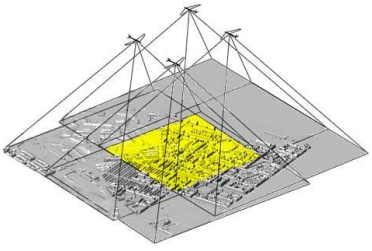
Orthophoto & Ortho-rectification

Orthophotos - orthographic photographs

- Photographs that do not have distortions nor displacements.

True orthophotos:

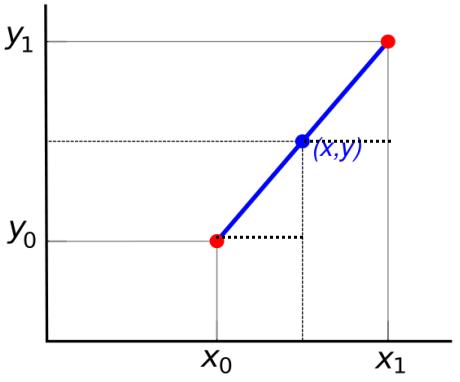
http://www.sharpgis.net/page/True-Orthophoto-Generation.aspx



How to tell if triangles are similar

- AAA are congruent (i.e., coincident)
- SSS in same proportion
- SAS (proportional sides next to congruent angle)

Known: x_0, y_0, x_1, y_1, and x
Find: y

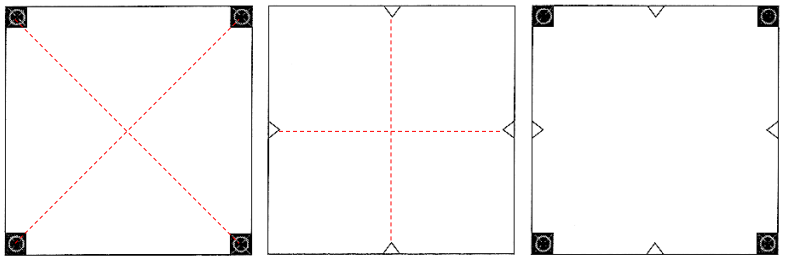


$$\frac{y - y_0}{y_1 - y_0} = \frac{x - x_0}{x_1 - x_0}$$

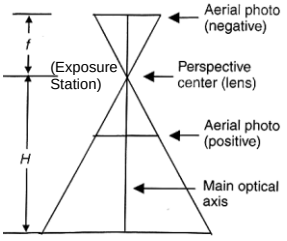
$$y = y_0 + (x - x_0)\frac{y_1 - y_0}{x_1 - x_0}$$

Basic Aerial Photography Geometry

- Fiducial marks
- Principal point

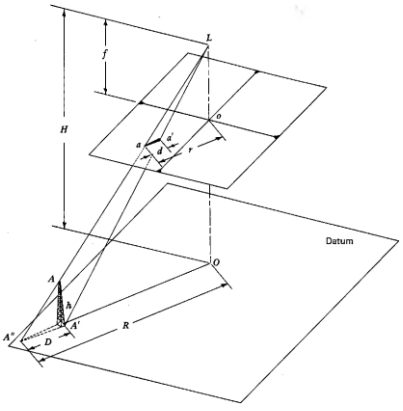


Geometric Components of Relief Displacement



$$\frac{1}{S} = \frac{f}{H}$$

1/S: photo scale
f: focal length of camera
H: flying height



$$d = \frac{rh}{H}$$

$$h = \frac{dH}{r}$$

d = relief displacement
h = object height
r = radial distance between location and PP on photo
H = flying height

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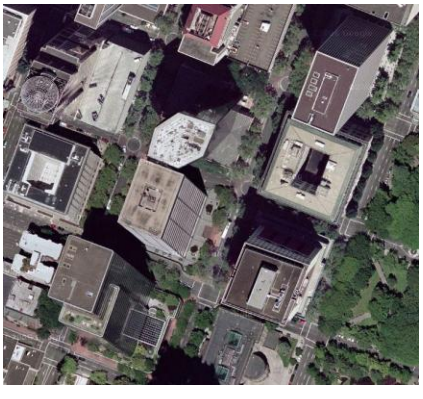
Relief Displacement



RD changes the measured distances and angles on photos.

Correcting for Relief Displacement: Orthorectification

$$d = \frac{rh}{H}$$

d = relief displacement
h = object height
r = radial distance between location and PP on photo
H = flying height

Image Parallax

- the apparent displacement or the difference in apparent direction of an object as seen from two different points not on a straight line with the object.

$$p_a = x_a - x'_a$$

p_a = parallax of point A
x_a = x coor of a on left photo
x'_a = x coor of a' on right photo

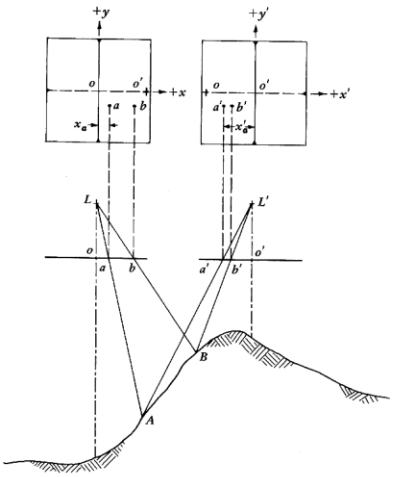


Figure 3.15 Parallax displacements on overlapping vertical photographs.

Figure 189: Exposure Stations Along a Flight Path

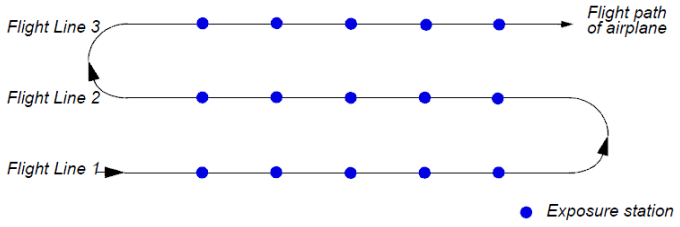


Figure 190: A Regular Rectangular Block of Aerial Photos

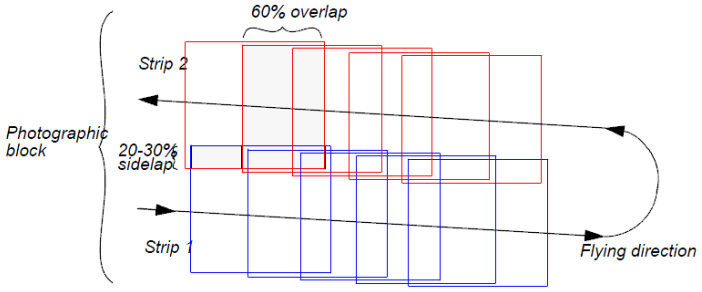
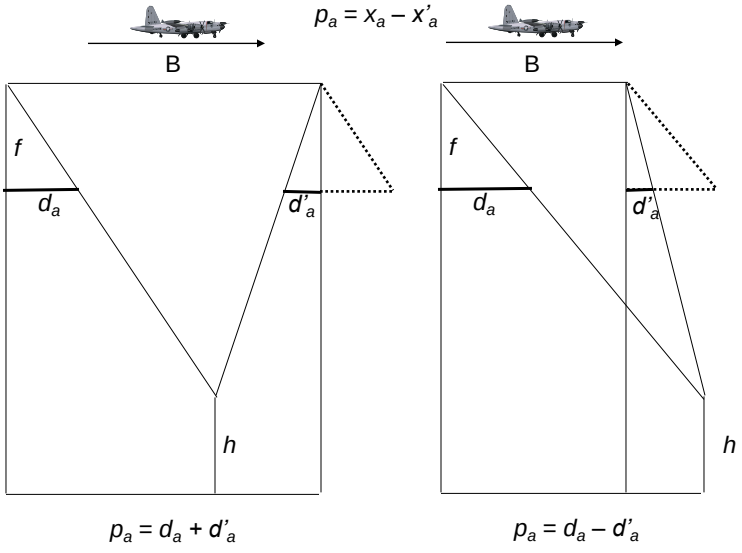


Image Parallax



Calculating Object Height & Location from Parallax

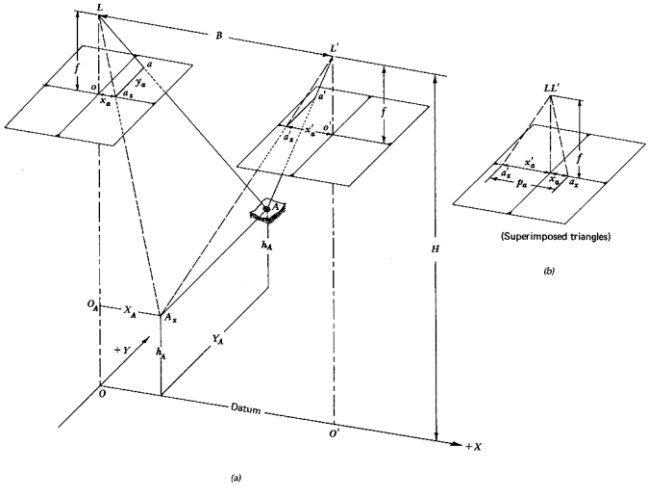


Figure 3.17 Parallax relationships on overlapping vertical photographs: (*a*) adjacent photographs forming a stereopair; (*b*) superimposition of right photograph onto left.

Parallax Equations:

$$h_A = H - \frac{B \times f}{p_a}$$

$$X_A = B\frac{x_a}{p_a}$$

$$Y_A = B\frac{y_a}{p_a}$$

p_a = parallax of A
x_a = x coor of A on left photo
X_A = ground coor of A
h_A = height of A
B = air base
H = flying height

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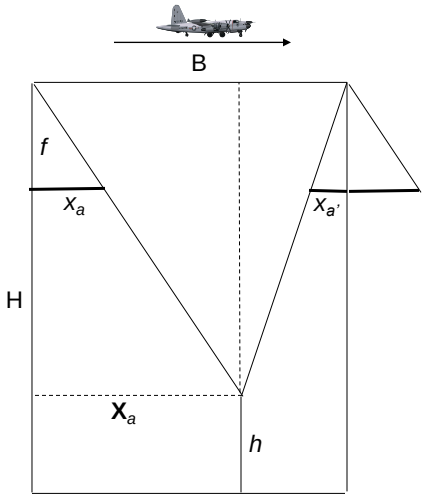
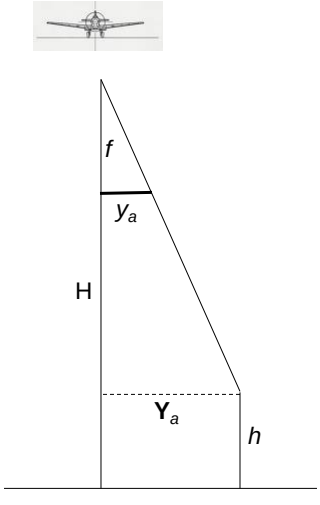
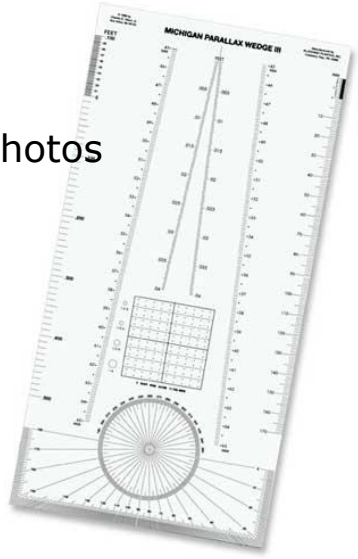


$$\frac{f}{x_a + x_{a'}} = \frac{H-h}{B} \qquad \frac{X_a}{H-h} = \frac{x_a}{f}$$



$$\frac{Y_a}{H-h} = \frac{y_a}{f}$$

Measuring Parallax



Based on a stereopair of photos

- Floating half marks
- Parallax wedge

Digital Photogrammetry:
Softcopy Photogrammetric Systems

- Scanned stereopair photos
- Interior and exterior orientations
  - Camera & photo parameters
  - Flight parameters
  - GCPs
- Image matching
  - Tie points
  - Algorithms
- Generate DEM and orthophotos

Collinearity Condition & Equations

- Alignment of exposure station (O), object location on the photo (p), and object location on the ground (P).
- If collinearity condition is achieved on both photos in a stereopair then the ground X, Y, Z can be computed from x and y within the image coordinate system on both photos.
- Six exterior orientation parameters
- Collinearity equations can be derived using GCPs.
- Inertial Measurement Unit (IMU)